DOCUMENT RESUME

ED 348 358 SP 033 996

AUTHOR McDiarmid, G. Williamson
TITLE The Arts and Sciences as Preparation for Teaching. Issue Paper 92-3.
INSTITUTION National Center for Research on Teacher Learning, East Lansing, MI.
SPONS AGENCY Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE Jul 92
NOTE 42p.
PUB TYPE Viewpoints (Opinion/Position Papers, Essays, etc.) (120)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Educational Principles; Education Majors; Elementary Secondary Education; *Faculty Development; Higher Education; *Knowledge Level; *Liberal Arts; *Preservice Teacher Education; *Teacher Education Curriculum; *Teacher Education Programs; Teacher Educators; Teaching Methods
IDENTIFIERS *Knowledge Base for Teaching

ABSTRACT

Policymakers have targeted what they perceive to be the inadequate content knowledge of teachers. Underlying resulting policies is an assumption that requiring prospective teachers to take more arts and sciences courses will remedy the problem. This paper examines whether or not this assumption is warranted. The discussion incorporates: critiques of undergraduate teaching; a view of knowledge for teaching; studying subject matter learning in the arts and sciences and the different kinds of knowledge teachers need; and investigations of students' understanding of subject matter and the teaching of subject matter in the arts and sciences emphasizing mathematics, writing, literature, and history. Prior research on student learning in arts and science courses is examined. It is argued that the problem is less one of ignorance about productive teaching practices and more one of cultural values; neither the disciplines nor research-oriented universities appear to value the learning of undergraduates as highly as grantsmanship or research. Implications for faculty development are discussed. (LL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED348358

Issue Paper 92-3

The Arts and Sciences as Preparation for Teaching

G. Williamson McDiarmid

NCRTL

National
Center for Research
on Teacher Learning

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

BEST COPY AVAILABLE

Sponsored by the United States Department of Education
Office of Education Research and Improvement

SP033996

Issue Paper 92-3

THE ARTS AND SCIENCES AS PREPARATION FOR TEACHING

G. Williamson McDiarmid

Published by

The National Center for Research on Teacher Learning
116 Erickson Hall
Michigan State University
East Lansing, Michigan 48824-1034

July 1992

This work is sponsored in part by the National Center for Research on Teacher Learning, College of Education, Michigan State University. The National Center for Research on Teacher Learning is funded primarily by the Office of Educational Research and Improvement, United States Department of Education. The opinions expressed in this paper do not necessarily represent the position, policy, or endorsement of the Office or the Department.

National Center for Research on Teacher Learning

The National Center for Research on Teacher Learning (NCRTL)[1] was founded at Michigan State University in 1985 with a grant from the Office of Educational Research and Improvement, U.S. Department of Education.

The NCRTL is committed to research that will contribute to the improvement of teacher education and teacher learning. To further its mission, the NCRTL publishes research reports, issue papers, technical series, conference proceedings, and special reports on contemporary issues in teacher education. For more information about the NCRTL or to be placed on its mailing list, please write to the Editor, National Center for Research on Teacher Learning, 116 Erickson Hall, Michigan State University, East Lansing, Michigan 48824-1034.

Director:	Mary M. Kennedy
Associate Director:	G. Williamson McDiarmid
Program Directors:	Linda Anderson, Deborah Ball, G.W. McDiarmid
Director of Dissemination:	Cass Book
Project Manager:	Steven A. Kirsner
Editor:	Sandra Gross
Communication Specialist:	Debra Peterson

Many papers published by the NCRTL are based on the Teacher Education and Learning to Teach Study (TELT), a single multisite longitudinal study. The researchers who have contributed to this study are listed below:

Marianne Amarel
Deborah Loewenberg Ball
Joyce Cain
Sandra Callis
Barbara Camilleri
Anne Chang
David K. Cohen
Ada Beth Cutler
Sharon Feiman-Nemser
Mary L. Gomez
Samgeun K. Kwon
Magdalene Lampert
Perry Lanier
Glenda Lappan
Sarah McCarthey
James Mead
Susan Melnick
Monica Mitchell
Harold Morgan
James Mosenthal
Gary Natriello
Barbara Neufeld
Lynn Paine
Michelle Parker
Richard Prawat
Pamela Schram
Trish Stoddart
M. Teresa Tatto
Sandra Wilcox
Suzanne Wilson
Lauren Young
Kenneth M. Zeichner
Karen K. Zumwalt

[1]Formerly known as the National Center for Research on Teacher Education (1985-1990), the Center was renamed in 1991.

6/92

Abstract

Recently, policymakers have targeted what they perceive to be the inadequate content knowledge of teachers. Underlying resulting policies is an assumption that requiring prospective teachers to take more arts and sciences courses will remedy the problem. Is this assumption warranted? Drawing on prior research on student learning in arts and science courses as well as his own research on prospective history teachers' knowledge, the author argues, "Not necessarily." He further contends that the problem is less one of ignorance about productive teaching practices and more one of cultural values. Neither the disciplines nor research-oriented universities appear to value the learning of undergraduates as highly as grantsmanship or research.

THE ARTS AND SCIENCES AS PREPARATION FOR TEACHING

G. Williamson McDiarmid[1]

Elementary and secondary teachers and schools have been under siege from various critics for decades. Typically, critics trace the problems they see in public school teaching back to teacher education, charging that education courses are intellectually vapid (for example, see Kramer, 1991). Yet, arts and science faculty, rather than their teacher education counterparts, have traditionally been responsible for teaching prospective teachers their subject matter. Teacher educators may not even regard teaching subject matter content as their responsibility, assuming that prospective teachers learn the content they need in their arts and science courses (Floden, McDiarmid, & Wiemers, 1990). One needn't be an apologist for teacher education to suggest that it has been a visible and easy target for critics—many of whom, incidentally, call arts and science departments home. As Tobias (1990) recently noted, college science professors tend to call for reforms of precollegiate teaching but remain remarkably uncritical of their own efforts: "Reformers . . . are most comfortable dealing with problems that have their origins (and, hence, their solutions) elsewhere" (p. 8).

In its recently completed four-year, longitudinal Teacher Education and Learning to Teach (TELT) study, researchers at the National Center for Research on Teacher Education (NCRTE) found what many people suspected and other investigators (for example, Cohen, Peterson, et al., 1990) have also found: Elementary and high school teachers frequently lack connected, conceptual understandings of the subject matters they are expected to teach (NCRTE, 1991). High school teachers major in the subject matter they teach and, in many institutions, must take the same required courses as all other majors. More importantly, the teachers in the TELT sample rarely reported encountering opportunities in college—either in arts and science or teacher education—much less in elementary or high school to develop the kind of deep, connected understanding of subject matters that some advocate as vital if teachers are to help diverse learners develop meaningful understandings (see Ball & McDiarmid, 1990).

Assertions that teachers frequently do not have the kind of subject matter understanding they need are puzzling. Aren't they taught the knowledge they need? In some cases—such as in mathematics—the answer is no. Few institutions offer mathematics courses that include number theory, for instance. Consequently, many teachers must rely

---

[1]G. Williamson McDiarmid, associate professor of teacher education, is the associate director of the National Center for Research on Teacher Learning. The author gratefully acknowledges the assistance of Lamar Fertig, Jaime Grinburg, Margaret Malenka, and Steve Smith in gathering and evaluating much of the material reviewed herein. Peter Vinten-Johansen provided thoughtful comments from an arts and science perspective.

on what they learned about numbers in elementary school. In other cases, however, teachers have attended courses—in mathematics or history or composition or physics—that do include topics or concepts that they are responsible for teaching. For instances, history majors planning to teach high school are generally required to take at least a survey course or two in American history. So what's going on? What are undergraduates learning in their arts and science courses? And how does what they learn prepare those who plan to teach learners who are likely to differ from them socially, ethnically, and even linguistically?

Many of the colleges and schools of education that constitute the Holmes Group are engaged, or, perhaps, more accurately, embroiled in transforming their traditional four-year, baccalaureate degrees into five-year programs. All teachers in such programs will be required to major or specialize in an academic subject matter. This reform is, in part, a response to the criticism, heard for years from a variety of quarters, that teachers lack adequate subject matter knowledge (Bestor, 1953/1985; Conant, 1963; Kramer, 1991; Rickover, 1960). Because they have traditionally regarded arts and science courses as the primary sources of subject matter knowledge for teachers, teacher educators and policymakers have lighted on more arts and science courses and fewer education courses as the remedy. Although this reform doubtless delights the myriad critics of education courses, the question remains: Will reforms requiring more arts and science courses result in prospective teachers developing more of the kinds of knowledge and understandings they need for teaching? In particular, how will requiring arts and science majors of teachers prepare them to teach in ways that enable diverse students to develop the kinds of critical and meaningful understandings called for by various reform proposals (American Association for the Advancement of Science, 1989; National Council of Teachers of Mathematics, 1989a; National Research Council, 1989, 1991)?

In what follows, I review some of the evidence that has been gathered on teaching and learning in arts and science courses. To write about higher education is to risk, as a matter of course, overgeneralizing. As more than 2,100 institutions grant baccalaureate degrees in the United States, few generalizations will hold across the full range of colleges and universities (Boyer, 1987). When one undertakes to write about teaching and learning, the number and variety of courses offered in these diverse institutions further compounds the dangers of over-generalizing. Certainly many students, particularly during their junior and senior years, experience inspiring classes in which they develop deep insights and meaningful, connected knowledge. Many students who attend liberal arts colleges, honors programs, or upper level courses in large public universities—institutions, programs, and instructors that pride themselves on their teaching—encounter teaching that is focused as

much on ensuring that students understand as on covering the subject. This is, nonetheless, but one story that can be told about teaching and learning in arts and science courses.

Critiques of Undergraduate Teaching

Another story to be told about teaching in higher education concerns a particular set of beliefs about teaching, learning, and knowledge that appear remarkably consistent over time. Edwin Slosson, a journalist who undertook a study of the "great American universities" in 1910, labelled the teaching he observed in the more than 100 classes he attended largely a "waste of time and energy." He reported "no lack of industry, devotion, and enthusiasm on the part of the teachers, but the educational results are not commensurate with the opportunities afforded and the efforts expended" (quoted in Smith, 1990, p. 214). Slosson found the lectures he attended not merely dry-as-dust but leadened by unnecessarily detailed information. Nearly 80 years later, Boyer (1987) and his associates observed classes in a stratified sample of 29 institutions of higher learning.

Presenting a picture of teaching and learning that differs little in substance or tone from Slosson's, Boyer notes that, "with few exceptions," his research team observed university faculty presenting information that "students passively received." Typically, these classes afforded "little opportunity for positions to be clarified or ideas challenged" (p. 150). Another researcher estimates that students listen to lectures about 80 percent of the time they are in class and attend to what the lecturer is saying about half the time (Pollio, 1984). After reviewing observational studies of university teaching, Dunkin and Barnes (1986) conclude that, just as in classes at other levels, the emphasis in most college courses is on "lower-level and convergent types of cognitive operations" (p. 763). If these investigators and others are to be believed, instruction that typifies many if not most undergraduate classes appears to have changed little over the course of this century.

And what a century: Not only has the sheer volume of information expanded numbingly but information—via electronic databases, on-line information services, CD-ROM, and other technologies—is more readily available to potentially more people than almost anyone could have foreseen even three or four decades ago. The ready availability of information in most fields through a variety of easily accessed sources raises questions about the efficacy of the lecture as a primarily a source of information. In addition, within colleges, a dramatic change has taken place in the student population: In most if not all the lecture halls he visited in 1910, Slosson observed almost exclusively young, male, and white students bent over notebooks. Lecturers who were themselves predominantly male and white could presume shared values, experiences, and expectations. Such presumptions no

longer pertain as student bodies have grown more socially, racially, and culturally diverse and the economic and technological environment has changed radically. Although the world has changed dramatically, college teaching apparently has not.

Perhaps college instruction hasn't changed because it is satisfactory. After all, some researchers have generated evidence that college graduates do, in fact, score higher on tests of verbal and mathematical skills than high school graduates—even after controlling for race, parent's education, father's occupation, gender, handicapped status, region of the country, high school mathematics courses, public/private school, and scores at time of high school graduation (for a review of this research, see Pascarella & Terenzini, 1991). After testing both freshmen and seniors on a variety of measures, including analyses of argument, tests of thematic analysis, and concept learning, Whitla (1977), for instance, has reported that the seniors consistently did better.

Many critics are not, however, persuaded. Perkins (1986), for example, asked students, both when they began and when they completed college, a series of questions that required them to reason informally. He concluded that students' capacities for such reasoning did not appear to be enhanced by the experience of college. A number of recent treatments have excoriated college teaching in language and tone reserved previously for secondary and elementary teaching. A National Research Council study (1991) of undergraduate mathematics described much university teaching as "casual." Rigden and Tobias (1991) report, based on the observations of faculty and graduate students from fields outside of science who attended undergraduate science classes, that the "basic ideas and concepts that compose science . . . receive little direct or explicit attention in introductory classrooms" (p. 52).

Noting that on most campuses "teaching is often viewed as a routine function, tacked on, something almost anyone can do" (Boyer, 1987, p. 23), Boyer recommends "a more inclusive view of what it means to be a scholar" (p. 24), a view that recognizes that knowledge is acquired through teaching as well as through research. Historian Page Smith (1990), in a scathing attack on universities in the United States, decries the "sorry state" of college teaching and overreliance on lecturing, noting that in more than 30 years in the university he can recall only five or six really good lecturers. Without dialogue in the classroom, Smith argues, no genuine education occurs.

In *Integrity in the College Curriculum*, the Project on Redefining the Meaning and Purpose of Baccalaureate Degrees (1985) bemoans the "transformation of the professors from teachers concerned with the characters and minds of their students to professional, scholars with PhD degrees with an allegiance to academic discipline stronger than their

commitment to teaching" (p. 6), although the authors do not reveal when this golden age of college teaching existed. Reacting to the passive role that it believes students play in most college courses, the Study Group on the Conditions of Excellence in American Higher Education (1984) calls on college faculty to design curriculum and instruction that engages students more actively—a recommendation consistent with the findings of Astin (1985) and other researchers (see Pascarella & Terenzini, 1991).

In short, if these various reports are to be believed, all is not well in the college classroom. The experience of developing knowledge and understandings that are connected and meaningful may not be as widespread as advocates of more arts and science courses for prospective teachers appear to assume. The authors of the Project on Redefining the Meaning and Purpose of Baccalaureate Degrees (1985) worry that the "decline and devaluation of the undergraduate degree," due in part to the frequently poor quality of undergraduate teaching, leaves graduates inadequately prepared for the business and corporate world. For those of us concerned with the education of teachers, a greater worry is that more prospective teachers are likely to be spending more time in arts and science classes, classes in which they are likely to encounter teaching that is, according to a number of critics and investigators, often mechanical and focused on disembodied detail, however well intended. What will prospective teachers learn in these courses? Will they, in fact, have opportunities to develop the knowledge and understandings required to help all children learn?

A View of Knowledge for Teaching

Before turning to the evidence on undergraduate learning in specific subject matters, I should describe the kind of content knowledge that a number of people have argued teachers need. One's notion about what teachers need to know about the subjects they teach is, after all, the basis from which one argues for what teachers ought to have the opportunity to learn. Regardless of their beliefs about what teachers need to know about the school subjects they teach, nearly everyone should be concerned about the evidence on teachers' knowledge of the subjects taught in schools. For those who believe that teachers need to know only what is conventionally included in the curriculum of schools in the United States—no more, no less—the evidence is that many undergraduates, including prospective teachers, do not know fundamental information and procedures in the subjects they must teach (Ball, 1988a, 1988b, 1989; Ball & Wilson, 1990; McDiarmid & Wilson, 1991; Ravitch, 1989; Rosaen, Roth, & Lanier, 1988).

Although knowledge of the contents of the conventional school curriculum may be sufficient for teaching some subjects, as the demands of schooling change, teachers will need to know more than the facts, events, procedures, ideas, and so on in the written school curriculum. Hirsch (1987) argues that, in addition to knowing who Grant is, "we need to know . . . the broad social and historical significance of the American Civil War" (p. 59). Calls for reform in the teaching of mathematics consistently include recommendations for greater attention to mathematical reasoning and problem solving, quantitative sense and power, and the capacity and inclination to use mathematics to make sense of everyday situations (National Council of Teachers of Mathematics, 1989a, 1989b; National Research Council, 1989, 1991). The goal of a recent national initiative to reform science teaching is the scientifically literate citizen

> who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. (American Association for the Advancement of Science, 1989, p. 4)

These calls for reform posit a kind of learning and knowing in the various subject matters—deeper, more connected, and more meaningful to the learner—than has generally occurred heretofore. To help increasingly diverse learners develop such knowledge, teachers will need knowledge that is, likewise, more connected, deeper, and more extensive than most teachers have had the opportunity to develop during their own schooling (National Council of Teachers of Mathematics, 1989b; Wilson & Sykes, 1989). Not only do they need such knowledge, but, as teachers, they also need to be able to organize their knowledge in ways that enable them to construct compelling and accurate explanations (Leinhardt, 1987; Leinhardt & Smith, 1985).

Indeed, some argue that knowledge of subject matter content and a general understanding of the field, although absolutely necessary, are not sufficient for teachers: Teachers also need to know about the subjects they teach (Anderson, 1991; Ball, 1991; Banks, 1971, 1991; Buchmann, 1984; Grossman, 1990; Scheffler, 1973; Shulman, 1986, 1987; Watts, 1972; Wilson, 1991) Knowing *about* a subject includes knowing how new knowledge is created or discovered and tested, major debates and disagreements in the field, the principal perspectives or "schools," how the field has developed, who has contributed to that

development, and who has not and why (Ball & McDiarmid, 1990; Kline, 1977; Schwab, 1964; Shulman, 1986; 1987; Watts, 1972).

Several arguments are made to support the idea that teachers need to learn *about* the subjects they teach. The argument made above is that teachers need such knowledge in order to help their learners develop similar understandings (Buchmann, 1984; Scheffler, 1973). An understanding of the nature of a subject also enhances learners' capacity to learn more on their own. Not only do they know where to look for new ideas and information, they have standards for evaluating these when they find them. A teacher with an understanding of how scientific knowledge evolves and the role of the scientific community in testing new knowledge claims could help students make better sense of controversies such as those over cold fusion research and genetic engineering than could a teacher who lacks such understandings. Such a capacity to judge the validity of competing claims and to learn on one's own is critical to a democratic society and to a world in which knowledge in nearly every field is growing at a dizzying pace.

The obligation to engage diverse students in learning is yet another argument (McDiarmid, 1991b). Understanding who has constructed the accounts of history that find their way into textbooks, curriculum guides, standardized tests, and so on, enables teachers to help students from groups whose roles in the past are frequently ignored, misrepresented, or underrepresented in these accounts understand why and how this happens and what this demonstrates about the nature of history (Banks, 1971). After reading summaries of four competing interpretations of Reconstruction, 16 history majors—half of whom plan to teach—in a required historiography course reported that they had encountered only one of these in high school (McDiarmid, Wiemers, & Fertig, 1991). The single interpretation they had encountered, moreover, casts African Americans in the post-war South as passive dupes of manipulative carpetbaggers—a view contested for more than 50 years (DuBois, 1935; Woodward, 1986) and revised by other historians beginning in the 1940s (Current, 1988; Foner, 1988), but one that apparently has yet to be displaced in many high schools or in the wider culture. What does this interpretation—associated loosely with William Dunning, a historian—convey to African-American students about their heritage and themselves? What does it convey to other students about African Americans? Without a critical perspective on the knowledge that finds its way into the curriculum, teachers are unprepared to help students develop a similarly critical stance—a stance vital for all students but particularly for those whose people have been excluded from the curriculum.

Knowing about the subject matter—for instance, that writing historical accounts involves interpreting as well as chronicling events—also helps teachers understand how ideas,

theories, facts, events, and interpretations are connected to form a "big picture" of a subject. Appreciating that experts in a field may disagree about the relative importance of various evidence or arguments, as well as about the relationships among these, teachers are well positioned to look for and make such connections in the various materials they and their students use. Teachers can then help students develop an overarching picture of events or epochs that goes beyond the skeletal information usually provided in various published materials.

Although they rarely do so consciously and deliberately, teachers communicate, as a matter of course, their understanding of the nature of the subject to their students (Beers, 1988). The teacher's understanding of the subject is embodied in the social organization and interactions of the classroom, the kinds of instructional tasks pupils do, the ways that instructional representations such as textbooks are treated, and the kinds of discourse the teacher encourages (Ball & McDiarmid, 1990; Doyle, 1986; McDiarmid, Ball, & Anderson, 1989; Wilson & Wineberg, 1988). Findings from observational studies of classrooms point out why this is currently problematic: Teachers tend to promote an uncritical view of validity claims (Young, 1987), leading students to develop assumptions that what is in books is "true," that scientific results are "correct," and that adults' claims must be well founded.

For instance, teachers who view history as little more than a chronicle of past events, who are not aware of the contentious and interpretive nature of historical knowledge, are likely to take an uncritical stance towards the textbooks they use. Recently, a variety of critics of history textbooks (Axtell, 1987; Fitzgerald, 1979; Gagnon, 1988; London, 1984; Sewall, 1987) have pointed out the dangers of such a stance. In both history and social studies, as in other subjects, elementary and secondary teachers "depend heavily on textbooks as their major source of course content" (Sewall, 1987, p. 62). The textbooks, these critics charge are, with but one or two exceptions, bloodless "catalogues of factual material about the past" (p. 65) that portray history as "just one damned thing after another" (Fitzgerald, 1979, p. 161). Without *both* considerable content knowledge *and* an understanding of the nature of history, teachers are at the mercy of such texts, unable to put textbook accounts into perspective or offer alternative interpretations (Wilson & Sykes, 1989, 1991). Comparable charges have been leveled at mathematics textbooks that typically "foster an algorithmic approach to the subject" (Ball & McDiarmid, 1990, p. 445). Small wonder that most pupils consistently rate these subjects among their least favorites and score low on tests of knowledge in these fields (National Research Council, 1989; Ravitch, 1989).

One final argument for teachers both knowing the content of the subjects they are to teach as well as knowing *about* that content—its construction, its growth, its development over time—is the critical ties between subject matter knowledge and the particular knowledge of subject matter needed for teaching that has been termed "pedagogical content knowledge" (Shulman, 1986, 1987). This phrase expresses the idea that teachers must both know the subject matter for themselves and be capable of representing the subject matter in ways that are true to the discipline and build bridges between learners from a variety of backgrounds and the subject. The empirical and conceptual work that has been done on pedagogical content knowledge is linked by a common theme: The necessity for teachers to attend to the interaction of pedagogy and content. Their capacity to attend to this interaction—to think through the implications of pedagogy for organizing and representing the subject and of the subject for their role, their students' roles, and for orchestrating their instruction—depends on their knowledge of the nature of knowing in the subjects they must teach (Ball, 1990; Ball & McDiarmid, 1990; Lampert, 1985; McDiarmid et al., 1989; Shulman, 1986, 1987; Wilson, Shulman, & Richert, 1987; Wilson & Sykes, 1989; Wilson & Wineberg, 1988).

In sum, critics whose expectations for teachers' subject matter knowledge range from the purely factual to knowledge about the nature of knowing in a field all seem to agree: As society's expectations for student learning rise, many teachers' knowledge of the subject matters they must teach will become increasingly inadequate to the task of helping pupils learn what they need to know. Arts and science courses continue to be a primary source of subject matter knowledge for prospective teachers. The movement to five-year programs, alternate routes, and state-mandated restrictions on courses in education foreshadows a even greater role for arts and science courses in educating prospective teachers. The knowledge and understandings that they develop in these courses must be, consequently, a primary concern to those intent on improving the education of teachers.

Studying Subject Matter Learning in the Arts and Sciences: Different Kinds of Knowledge

Researchers have been studying what students learn in college for decades. In so doing, they have used a variety of instruments in an effort to measure the impact of college. Most frequently, the instrument of choice has been a standardized instrument such as the Scholastic Aptitude Test, the American College Test, or the Graduate Record Examination—paper-and-pencil, multiple choice tests (Pascarella & Terenzini, 1991). The reasons for this are obvious: The fact that these tests are "standardized" means that student performances can be compared regardless of "treatment." This allows the researcher to

compare the relative effectiveness of different treatments. The downside of such instruments are also obvious: They reveal little about *why* students answer the way they do and they measure a limited range of knowledge. If investigators are studying a treatment in order to understand, say, how to make the teaching of fractions better, knowing that most of the students in the sample cannot choose a correct example to illustrate 1 3/4 divided by 1/2 provides little information that serves the purpose of instructional improvement. Researchers know only that the treatment under study doesn't seem to help students develop such knowledge.

These instruments do not even register other types of knowledge—for instance, student understanding of what a fraction is and the different ways fractions can be interpreted and are used. Moreover, for those interested in the education of teachers, even knowing that a few prospective teachers can choose the correct answer for a calculation reveals little about whether they would be able to help learners figure out similar problems.

Pascarella and Terenzini (1991) who have reviewed the research on undergraduate learning of subject matter conclude that "the more a student studies in a particular area of knowledge . . . the more the student knows in terms of the knowledge and skills specific to that area" (p. 65). This conclusion relies almost exclusively on studies that have measured learning on standardized tests. These may tell us whether or not students can choose the correct response from five presented but they tell us little about the *nature* of student learning; that is, What sort of a framework do students bring with them to make sense of the discrete information and procedures presented on most standardized tests? How will this framework serve them in learning new information and ideas in the subject? These questions are crucial because of the role prospective teachers must play in helping their students develop frameworks that are both personally meaningful and accurate and serve them well in future learning.

Another approach to studying what undergraduates learn is to examine students' understanding of concepts that are fundamental, in the eyes of those in the field, to a particular subject matter. For instance, in history, a fundamental notion, debated for years, is objectivity (Novick, 1988). Objectivity has been such a controversial notion for so long because historians, in writing history, cannot avoid it. What stance will the historian adopt toward the evidence from and about the past and towards the actors on the stage of the past?

This question is at the heart of Schama's (1991) provocative *Dead Certainties (Unwarranted Speculations)*. How do historians steer between the Scylla of presentism—in which past events and actions are judged by the moral standards of their own age—and the

Charybdis of what Schama terms, in his subtitle, "unwarranted speculations" about the past and about the characters and happenings in the past? The latter is particularly dangerous if the historian conceives of his or her task—as many do—as imaginatively recreating the past, projecting themselves into the past in order to understand the motives of those involved in a given set of events. And, as Novick (1988) meticulously details in his study of the "objectivity question" in American history, the standards for judging the validity and sufficiency of warrants change over time and circumstances. What one generation may have accepted unquestioningly as warranted speculations may be regarded by the next as tenuous guesswork.

What has this issue to do with teaching and with studying the learning of prospective teachers? Teachers depend on various accounts of the past, usually those included in textbooks. Without some understanding of how historians think about writing history, of the various stances historians could adopt, teachers have little perspective on the accounts they and their students encounter. Lacking an appreciation for the many mansions that constitute the house of history (Hexter, 1979) and for the socially constructed nature of historical accounts, prospective teachers are unlikely to be prepared and disposed to help students assume a critical stance towards those accounts. And possible approaches are abundant—from the putatively dispassionate analyses of "cliometricians" who borrow quantitative methods from the social sciences to the rich, explanatory narratives of such historians as Francis Parkman, Jack Hexter, G. R. Elton, Garrett Mattingly, and Barbara Tuchman to the panoramic accounts of Fernand Braudel and his epigones in the French *Annales* school for whom enduring geographic, technical, and administrative "structures" are as much a part of history as are narratives of people, politics, and events to yet many other perspectives.

Moreover, without an understanding of the standards historians apply in judging the adequacy of historical works, teachers are ill prepared to help their students learn how to look at historical accounts critically. Recall the earlier example of the Reconstruction. The accounts that those in the so-called Dunning School wrote of Reconstruction were inadequate not because their portrayals of African Americans were so politically and morally unpalatable but also because they were not true. Rather than a scholarly product, their point of view represented "a regional white consensus" (Woodward, 1986, p. 24). Their racist premises led them to view past events in a particular light, to slight some events and people and magnify others beyond what historians who did not share their prejudices believed justified, to paper over "the breaks and fissures and conflicts in Southern history with myths of solidarity and continuity" (Woodward, 1986, p. 27), and to reach conclusions

not supported by all the available evidence (Foner, 1988). By the standards of both contemporary (DuBois, 1935; Lynch, 1913) and later historians (Foner, 1988; Woodward, 1986) the accounts of historians in the Dunning School are fatally flawed by their assumptions.

Standardized tests are ill suited to gauging the degree to which students perceive history as a debate, as an argument over the meaning of events in the past, and of written history as constructions that must be judged by how well they account for what is known about the past. The investigator needs to see evidence of how the student reasons about the task not in general but in relation to specific moments in history. As Watts argues (1972), historical knowledge is concrete; it does not evolve from the concrete to the abstract but from "a simple understanding of the concrete to a more sophisticated understanding of the concrete" (p. 54). Historians thrive on details, on the particularities and peculiarities of the past. What problems do historians encounter in writing accounts of the origins of the Civil War? How do these compare with the problems historians face in writing about the civil rights movement? When students are asked to discuss the problems of writing the history of a particular set of events in the past, what emerges is more than whether or not they know concepts such as reliability: They reveal their notions of evidence, the sufficiency of evidence, and the role of the historian as a product of his or her time and circumstances (McDiarmid, Wiemers, & Fertig, 1991). This lies close to the bone of what teachers in a variety of disciplines work to help students learn: To resist the inclination to reach premature conclusions, to suspend judgment until they have gathered and evaluated available evidence.

The Teaching-Learning Connection

The limited applicability of most existing research on undergraduate learning for addressing the issues of concern to teacher educators is not due merely to what kind of knowledge is measured. Some researchers have, in fact, tried to measure change in what Pascarella and Terenzini (1991) term undergraduates' "cognitive skills and intellectual growth" (p. 114). These researchers attend, however, to changes in general dimensions of knowledge—formal operations reasoning, critical thinking, communications, reflective judgment, conceptual complexity (Pascarella & Terenzini, 1991)—believed applicable to a range of disciplines rather than to student understanding of ideas, information, procedures, methods, controversies that are specific to a subject matter.

Figuring out what and how undergraduates learn from their arts and science classes requires that we look not only at what they seem to learn but also at the opportunities they

encounter to learn. Why do many prospective teachers fail to learn critical knowledge in and about a subject matter? To what degree is this due to the nature of the opportunities they have to learn, to the sheer complexity and difficulties of some of the ideas and concepts themselves, to the students' capacity or readiness to handle particular information and ideas, or to other factors?

To begin to address these questions requires that investigators gather information on learning opportunities in arts and science courses. Again, a substantial body of research exists on teaching in arts and science courses (a number of reviews of this literature exist, including Dunkin & Barnes, 1986; Kulik & Kulik, 1979; McKeachie, Pintrich, Lin, & Smith, 1986; Pascarella & Terenzini, 1991). Much of this research follows the lead of similar studies of teaching at the precollegiate level; that is, the research focuses on teaching behaviors or teaching formats—lecture versus discussion versus individual instruction. For example, some researchers (Hines, Cruickshank, & Kennedy, 1985) have found that gains in student achievement are correlated with certain teaching behaviors—such as using relevant examples, reviewing materials, asking questions, step-by-step teaching, allowing time for students to think after explanations, explaining the object of the lesson, and so on.

Pascarella and Terenzini (1991) report on studies that have examined the effects of various instructional approaches—such as the approach Karplus (1974) terms the "inquiry or learning cycle"—on general dimensions of cognitive development, for example, the transition from concrete to formal reasoning, the development of critical thinking (McMillan, 1987) and postformal reasoning. Some of the most potentially useful investigations in this area focused on an innovative freshman-year curriculum—Accent on Developing Abstract Processes of Thought (ADAPT)—at the University of Nebraska that used the inquiry or learning cycle approach (Tomlinson-Kreasey & Eisert, 1978). The researchers report that faculty in six different disciplines adopted the innovative approach. Because the researchers provide scant descriptions of the classes themselves and measured student learning with instruments designed to register generic knowledge and attitudes, the reader learns little about students' actual experiences in ADAPT courses, much less the sense students made of these experiences.

Winter, McClelland, and Stewart (1981) sought to discover whether students who attended a liberal arts institution demonstrated changes in several dimensions of cognition, particularly critical thinking, in comparison to students attending a state teachers' college and a community college. To measure changes in critical thinking, they developed an interview instrument, the Test of Thematic Analysis, designed to avoid favoring majors in a particular discipline. Students had 30 minutes to write a comparison of two groups of

brief stories. Although they report that the liberal arts experience contributed to growth in critical thinking, the researchers provide few details of the learning experience the students encountered. What about the liberal arts academic experience contributes to critical thinking isn't clear.

In short, much of the existing research on teaching and learning in arts and science courses is not particularly helpful in thinking about the kind of subject matter knowledge prospective teachers develop in relation to specific learning opportunities. Most of this work has used standardized tests to measure gains in subject matter knowledge—tests not designed to measure the changes in some of the kinds of knowledge which are *arguably critical* to a genuine understanding of a subject and to teaching. Researchers, moreover, provide few details about the kinds of learning opportunities students in their studies encounter. Much of the research that does focus on teaching has, in the mode of similar work on precollegiate teaching, examined generic teaching behaviors—the type and frequency of the teacher's question, whether or not the teacher reviews the previous lessons, how the teacher treats students' ideas, and so on. Findings of such research might be useful to faculty in changing particular behaviors—for example, accepting and using students' ideas. What seems less clear is how this work contributes to helping faculty who teach undergraduates understand what is difficult about teaching and learning—and learning *about*—such things as differential calculus, the mechanics of moving bodies, the narrator's use of anachronistic allusions in *Middle Passage* (Johnson, 1990), or crafting and supporting a thesis about an historical event. What does it mean to accept and use students' ideas in mechanics when these are, from a physicist's point of view, just plain wrong?

Investigations of Students' Understanding of Subject Matter and the Teaching of Subject Matter in the Arts and Sciences

Investigations of students' understandings of subject matter and the teaching of subject matter do, however, exist. Typically, these do not find their way into reviews, even one as extensive and thorough as that conducted by Pascarella and Terenzini (1991). Rather, they are often the product of investigators who are subject matter experts—mathematicians, physicists, English scholars—rather than researchers who study higher education or adult learning. They frequently undertake to find out what their students do and do not understand about the subject matter—and why. Typically, to find out, these investigators collect various kinds of information on students' understanding: interview data, student writing, and observations of students engaged in activities designed to reveal their understanding. And because of the kinds of questions these researchers wish to address and the kind of data needed to do so, the samples are small.

The advance of this type of inquiry has been uneven. In both physics and mathematics, a core of scholars have been investigating and reporting on students' learning and understandings for several years. Composition is another subject in which scholars have explored students' understandings in relation to the opportunities to learn. Graves (1981), a pioneering and influential scholar in the field, is a proponent of case-study inquiries into the teaching of writing. Attention to the development of students as writers has had some limited spillover effect in literature, particularly among faculty who view literature and writing as two sides of the same intellectual and pedagogical coin. In other areas, such as history, I have been unable to locate reports of systematic inquiry into undergraduates' learning beyond my own work.

Physics. Particular patterns in the persistent misunderstandings students manifest about mechanics have for years puzzled and frustrated faculty who teach undergraduate physics courses. In one study, a significant number of college physics students—about four out of five—predicted that the heavier of two objects of the same size and shapes would fall faster (Champagne, Gunstone, & Klopfer, 1985). Even in their second course in mechanics and after numerous counterexamples, students persist in believing that motion requires a constant force acting in the direction of the movement. Many students continue to believe that for an object such as a pendulum to remain in motion it must be acted on by a constant force propelling it in the direction of its motion (McDermott, 1984). Ninety percent of engineering majors who had yet to take a course in mechanics and 70 percent of those who had finished the course believed that two forces act on a coin that has reached the midpoint in its trajectory after being tossed into the air. In addition to the force of gravity, these students believed that the force exerted by the hand that tossed the coin continued to act on the coin in flight (Clement, 1982).

To find out why students' beliefs withstood the best efforts of physics instructors, faculty began to interview their students. They discovered that the students tend to draw on their own experience of the physical world in developing an implicit theory about bodies in motion; that is, the commonsense understanding of the relationship of force, motion, and direction that they have built up over years of experience overrides the principled explanation they encounter in their formal course work.

Students are not alone in their beliefs. Relying on his experience of the world, which apparently was much like that of the physics students described above, Aristotle similarly assumed that motion implies a force in the direction the object is moving. Aristotle's view appears to have been virtually unchallenged down to the time of Newton largely because he "merely formulated the most commonplace experiences in the matter of motion as

universal scientific propositions" while Newtonian physics, on the other hand, "makes assertions which are not only are never confirmed by everyday experience, but whose direct experimental verification is fundamentally impossible" (Dijksterhuis, 1969, p. 30).

McDermott (1984) describes research on students' understanding of force and motion conducted by Laurence Viennot at the University of Paris that has led him to evolve a model of student understanding of mechanics. Viennot (1979) believes that students may, simultaneously, hold both Newtonian and non-Newtonian ideas of force. The conception on which they rely to make sense of a given situation depends upon the circumstances in which they confront representations of force. Confronting representations of motion, velocity, and acceleration that instructors designed to challenge students' commonsense conceptions, students could compare their implicit theories with physicists' understandings of motion and force (McDermott, 1984; Trowbridge & McDermott, 1981). Champagne, Gunstone, and Klopfer (1985), Rosenquist and McDermott (1987), and Arons (1990) describe examples of physics instruction that draw on studies of students' conceptions and are designed to confront students' commonsense ideas as well as evidence that such approaches apparently succeed with many students.

The research of Viennot, Champagne, McDermott, Arons, and others raises several issues. First of all, it reveals the shortcomings of much "teaching-as-usual" in college physics. As Arons (1990) notes:

> Deficiencies in assimilation and understanding of the concepts remain concealed from us physics teachers partly because of our own wishful thinking regarding the lucidity of our presentations and partly because conventional homework problems and test questions do not reveal the true state of student thinking and comprehension. It is tempting to believe that adequate performance on conventional end-of-the-chapter problems indicates understanding, but, in fact, it does not. (p. 38)

These studies also underline the potential of pedagogy, tailored to confront students' habitual ways of thinking about the world, to challenge and apparently change students' beliefs—in this case, about mechanics. A number of scholars (Ball, 1988b; Ball, 1989; Bird, 1991; King & Ladson-Billings, 1990; McDiarmid, 1990) have described their attempts to challenge prospective teachers' beliefs about teaching. Creating nonevaluative opportunities for students to explain their understandings of fundamental concepts—such as force, motion, learning, teaching, student diversity—are common to these experiences in two quite distinct subject matters. Also similar across both physics and pedagogy are instructors who used

information about their students' initial understandings to design experiences that would lead their students to reflect critically on the adequacy of these understandings.

Interested principally in why more successful undergraduates do not major in science, Tobias (1990) enlisted seven postgraduates—all of whom had been science avoiders in college but had succeeded in another field—to audit introductory courses in physics, chemistry, and mathematics. These surrogate undergraduates not only did all the work in the course but kept notes on their experience, the instructor, and their classmates. The auditors most frequently complained that their instructors failed to provide them with "road maps" of the subject matter, some indication of where they were and where they were going. One wrote: "I never really knew where we were heading or how much, in the real scheme of things, we had already covered. Each topic the professor discusses feels like it's being pulled out of a hat" (p. 38). This same auditor, as well as the others, bemoaned what Tobias terms the "tyranny of techniques": "They hungered—all of them—for information about how the various methods they were learning had come to be, *why* physicists and chemists understand nature the way they do, and *what* were the connections between what they were learning and the larger world" (p. 81). In addition, as humanities scholars, the auditors were unprepared for what they perceived as the lack of community that resulted, Tobias and the auditors believe, from large class sizes and competition among students.

Asked to comment on an auditor's observation that his course was dull, a chemistry instructor wrote: "'It is dull. It is dull to learn, and it is dull to teach. Unfortunately, it is the basic nuts and bolts stuff that must be mastered before anything useful can be accomplished'" (Tobias, p. 55). Instructors in a variety of fields and across many decades have defended the dreariness of their courses in similar terms. Sixty years ago, for instance, Howard Mumford Jones rationalized the pedantry of his American literature courses in these words: "No conscientious teacher . . . but realizes with regret that his days and nights are practically given over to the teaching of obvious and necessary information and technique; and though he would gladly push on to higher matters, practically he is unable to do so" (quoted in Graff, 1987, p. 142).

Underlying the comment made by the chemistry instructor in Tobias's study is a view of the structure of knowledge in chemistry as hierarchical. Although this helps explain why this instructor—and probably many others both in chemistry and other disciplines—organize their content as they do, the comment also raises questions about such perceptions, questions that only subject-matter specialists can discuss fruitfully. Do other views of chemical knowledge exist? If so, do they imply other ways of organizing the content? If there is only one structure of knowledge in chemistry, does it follow that information, ideas,

and procedures have to be taught hierarchically? Does this approach to chemistry and the teaching of chemistry systematically limit access to groups of learners such as women? The data Tobias presents does not suggest that the faculty who taught the courses in this study were provoked to such considerations by the comments of the auditors.

Although all of the Tobias's auditors succeeded in the courses they took, all were intellectually frustrated, to greater and lesser degrees, not by the subject but by the way the subject was taught. This was true even in those instances in which the auditor was profoundly interested in the subject. If people, like the auditors in this study, who possess sophisticated habits of mind and considerable resources for integrating new knowledge with old and making sense of arcane material on their own are turned off by the way science is taught, one can imagine the effect on most undergraduates.

Mathematics. In mathematics, research on students' understandings has revealed that many may lack understanding of fundamental ideas despite their apparent success in university mathematics courses. A number of recent studies (Clement, 1982; Clement, Lochhead, & Monk, 1981; Maestre, Gerace, & Lochhead, 1983; Maestre & Lochhead, 1983) have demonstrated the inability of undergraduates majoring in science and engineering to represent correctly a simple algebraic relationship between two variables—to wit, the famous "student-professor" problem: "Write an equation using the variables S and P to represent the following statement: 'There are six times as many students as professors at this university.' Use S for the number of students and P for the number of professors" (Maestre & Lochhead, 1983).

Typically, students who offer an incorrect equation reverse the variables as follows: $6S = P$. Clement and his colleagues (1981) report that over one-third of the engineering students they tested and nearly 6 out of 10 nonscience majors could not offer an appropriate representation. Through interviews with the students and varying the form of the problem, the researchers discovered that the reversal is not merely carelessness but is systematic. Many students, even when they have mastered the mechanics of the subject, apparently fail to develop an understanding of the underlying meanings.

Ball (1988a) reports that whereas mathematics majors planning to teach produced more correct answers for division involving fractions, zero, and algebraic equations than did elementary education majors, the math majors frequently struggled in "making sense of division with fractions, connecting mathematics to the real world, and coming up with explanations that go beyond restatement of the rules" (p. 39). Schoenfeld (1985) reports on his undergraduates, most of whom had previously done well in college calculus as well as in high school geometry, and their efforts to solve fairly simple geometric problems.

Although the students, working as a group, could solve the problems, they struggled to explain why the solutions worked, Schoenfeld reports: "My class spent a week (at the college level) uncovering the reasons for two constructions that they had been able to produce from memory in less than two minutes" (p. 376).

In both physics and mathematics, evidence is mounting that all students, not just those intending to be teachers, can meet instructors' expectations for satisfactory work *without* developing a conceptual understanding of the subject matter—the lack of which, we have argued, seriously inhibits teachers' capacities to help school pupils learn in ways that are meaningful. This is, no doubt, unsurprising: Many of us, I would hazard to claim, have had the experience of cramming for an exam and doing well and, yet, realizing that we really did not understand much of the information and procedures with which we stuffed out memory.

Writing and literature. As mentioned above, the reorientation of many composition instructors to writing as a process and students as working writers has produced a number of small-scale studies. Typical of this work is Coleman's (1984) ethnographic study of five students in her introductory undergraduate writing course. Coleman used learning logs and peer response groups both to help her students develop their ideas about writing as well as to document the evolution of their thinking and writing. Ritchie (1989) followed the development of two students in an introductory composition course taught as a writers' workshop in which she was a participant-observer. Drawing on interviews and observations of the students and on the evolution of their written work, Ritchie identifies four aspects of their experience she believes critical to the growth in their writing ability: their personal histories, the assumptions about writing and learning to write that the students bring with them from their prior education, the nonauthoritative role the instructor assumed, and the response of students to one another's writing.

Miller (1983) has examined how three student-teachers thought of themselves as writers and of the writing process. As they started to teach, the student-teachers found the lack of an integrated writing experience in their own past limited and undermined their own desire to teach writing and literature in a more integrated way: "Because they, themselves, had only experienced writing as a segmented and grammar-bound process, they were unable to fully implement the theoretical constructs which they had studied in their preparatory courses with confidence or even enthusiasm" (p. 13).

To find out how English majors planning to teach differ from those majors who did not plan to teach, Clift (1987) interviewed three from each group. She asked them about English as a subject of inquiry, about their experiences in learning English, about teaching

English, and about learners in the English classroom. She found that the two groups responded similarly to questions about organizing concepts related to English but differed on their views of learners and on who has the authority to interpret literature. For instance, English majors not planning to teach seemed more inclined to believe that the professor's view of literature is most important and part of the student's task is to figure out how the instructor interprets a text and style their papers according to the professor's bent: "Like I use the historical approach in X's and I would use the psychological approach in Y's class" (p. 232). These students preferred the approach to teaching they had experienced in university English classes, believing that time devoted to discussion should be limited. The English majors who intended to teach seemed, on the other hand, more inclined to try to involve learners in interpreting literature through identifying with the characters.

Small-scale studies of the learning of composition and literature such as these suggest a couple of issues. The studies that focused on academic majors who plan to teach highlight the role of the undergraduates' prior experience with learning the subject. This experience strongly influences their capacity to adopt unfamiliar pedagogical roles and approaches. In general, these studies underline the salience of the ideas and understandings undergraduates bring with them to the kinds of understandings they develop in college.

History. Our search for studies of teaching and learning history at the university level produced little. Nicholls (1984) and Simmonds (1989), both members of history faculties at British universities, have collected data on the undergraduate history curriculum and the teaching of undergraduate history in the United States. Nicholls surveyed eight of his compatriots who taught at American colleges and universities under the Fulbright program. Summarizing his respondents' views, he writes,

> History courses were perceived as being organized around a lecture program and an accompanying text, with these two vehicles assuming excessive weight in the overall scheme of things, while the information thus imparted was later "retrieved" by some "objective" test to measure just how much of it the excessively grade-conscious student had ingested. (p. 65)

Simmonds (1989) visited 23 institutions—from small private liberal arts colleges to large state research universities—to observe classes and to interview faculty and department chairs. Many of the classes he observed conformed to the image reported in Nicholls: "Teaching methods often seemed purely didactic." Simmonds is quick to point out that the sheer numbers of students in these classes appeared to preclude any genuine discussion. Historical knowledge itself, he further reports, was presented, at least in lower division

courses, as undisputed. Finally, he comments that course work for a major in history remains at many institutions a patchwork: "Overall there is no concern that students take courses which progress towards a final piece of work, or courses that interrelate to develop a coherent pattern of study" (p. 313).

O'Brien (1984) describes an intriguing American history survey course he taught that involved community college students in making their own sense of historical "moments" while he provided data and guidance. He fails, however, to present sufficient information on student learning to allow the reader to assess his approach. Others, such as Cannon (1984) have urged, on the basis of their own experience, particular approaches to pedagogy and curriculum. These typically, however, contain little or no information on how the author came to believe what he or she believes about teaching, much less data that would allow the reader to determine the efficacy of the recommended approach.

McDiarmid and his colleagues (McDiarmid, 1991a; McDiarmid, Wiemers, & Fertig, 1991) have examined a required historiography course taken by both prospective teachers and nonteachers. The researchers selected the course to study because it was billed as "history workshop" and thus represented learning opportunities not usually present in lecture courses. In addition to observing all meetings of the course and tape recording the instructor's conferences with individual students, they interviewed the instructor and the students before and after the class and collected copies of the students' written work with the instructor's comments.

McDiarmid found that the instructor's pedagogical goals grew out of his knowledge of both the students and history. For instance, the structured writing assignment in the course required the students to identify an author's thesis and the evidence supporting the thesis and then, subsequently, to craft theses of their own about an event that professional historians have not attempted to explain (McDiarmid, 1991a). Making convincing arguments about the past, the instructor believes, lies at the heart of writing history. He also realizes that most of his students will come with little or no experience in constructing sound arguments and, consequently, will need a series of activities structured to help them.

In addition to describing and analyzing the learning opportunities in the workshop, McDiarmid and his colleagues describe the students' knowledge and understanding during and after the course. They analyze data on students' experiences with learning history, their knowledge of specific facts about events typically taught in high school (i.e., the Civil War and the civil rights movement), their understanding of how historical accounts are constructed, their dispositions toward conflicting accounts of the same events, and their

views of teaching and learning history. Although these researchers have reported only preliminary results, several themes run through their work.

For instance, most of the central ideas about history to which the students are exposed—such as the notion of objectivity and history as a social and historical construction—are the subject of intensive and protracted debate among professional historians. That students, even after an experience they view positively and appears to the observer to offer numerous chances to learn, continue to struggle with such "big" ideas is not a surprise. Moreover, while in the long-term process of struggling with more sophisticated and critical notions of historical knowledge, students may be ill prepared to consider the implications of these ideas, still unformed in many cases, for teaching and learning. Hence, when asked how they would teach secondary students the origins of the American Civil War, they fall back on what they remember of their own experiences in high school. They seem to believe either that they are incapable of creating the kinds of opportunities to learn that they experienced in the historiography workshop or that most high school students are incapable of learning from such experiences.

In sum, a growing body of literature in several disciplinary areas—physics, mathematics, and composition, in particular—focuses on the learning of the knowledge in these disciplines and, in some cases, examines student learning in relation to specific opportunities. Both collecting information on student subject matter knowledge and understanding from a variety of sources and attending to learning in response to particular opportunities tend to distinguish these investigations from those that have focused on narrow definitions of learning, generic cognitive skills, and teaching as a set of generic techniques. At the same time, because of the case-study or small-sample nature of this research as well as its subject-specific focus, results from this work cannot be generalized broadly.

This research is, nonetheless, suggestive. Much of it reveals, in a variety of fields, the salience of the understandings students bring with them to their encounters with subject matter in the college classroom. Such understandings can frustrate or facilitate university teachers' efforts to bring about understandings of ideas, processes, and phenomena thought fundamental in their fields (Duckworth, 1987). Further, this research highlights the difficulty of many of these fundamental understandings. University faculty, accustomed as they are to thinking within the ideas and concepts of their field, may underestimate the difficulty of many of these ideas and concepts for undergraduates. The pedagogical problem of assisting students in grasping difficult ideas seems to be compounded by the belief among many faculty that they must cover certain topics or fail in their responsibility to prepare the student for subsequent courses in the field. Rather than devote more time to certain ideas,

faculty feel they must hurry on, fearful they will not finish the syllabus. Finally, the research focused on the teaching of particular subject matters underlines the problems with pedagogy that concerns itself with representing the subject matter faithfully, largely ignoring both what learners bring with them and possible alternative ways of organizing the content that may be both true to the field and more accessible to more students.

Conclusion: Implications for Faculty Development

The evidence on undergraduate learning in arts and science courses seems mixed. Some research appears to show that students may learn certain factual subject matter knowledge and generic cognitive skills from their undergraduate education. In contrast, closer examinations of student learning in specific subject matters raise questions about the kinds of knowledge students develop, particularly about their understandings of fundamental concepts in arts and science courses—such topics as mechanics in physics, algebraic and geometric relationships, the nature of historical accounts, the purpose and process of writing, and the interpretation of literary texts.

Given the sheer difficulty of these and many of the other ideas and procedures students encounter, that many students misunderstand or understand incompletely or imperfectly is not surprising. Not understanding, for many students, presents no major impediment to their succeeding quite well in most careers. Marketing managers may succeed brilliantly despite believing that a constant force acting in the direction of the motion of a pendulum is required to keep it moving, that 7 divided by 0 is 0 rather than being undefined, or that during Reconstruction unscrupulous carpetbaggers and ignorant blacks wreaked havoc on the prostrate South. In contrast, appreciating the nuances and implications of these and other ideas, their compatibility with related concepts, and their robustness in the face of close examination is arguably essential to a critical stance towards knowledge in any field. Such a critical stance towards, for example, historical knowledge may be essential to full, contributing membership in the variety of communities that make up a democracy.

But granting for a moment that most undergraduates would not be appreciably hindered by inaccurate or incomplete understandings of various subject matters, the same may not be said of teachers responsible for teaching the subject matters. Much of the current reform effort consists of educating learners both to know more about the subjects taught in school and to take a more critical view of knowledge. To help diverse students achieve these goals, teachers themselves need deeper, more connected, and more critical knowledge and understandings.

Given the current policy drift toward more arts and science and less education courses, what are the prospects that teachers will develop such knowledge during their undergraduate years? From the evidence on arts and science teaching and learning, the prospects seem to be slim, at best. In fact, at the very time that policymakers and teacher educators have decided to increase prospective teachers' exposure to arts and science courses as formal preparation for teaching, institutions of higher education are in the grip of another fiscal crisis that is exacerbating some of the conditions that contribute to the ineffectiveness of much college teaching. Class sizes are increasing, survey courses—the money cows of many departments—are likely to become more common, and faculty are coming under increasing pressure to teach more. Increasingly at some institutions, part-timers are hired to teach introductory and service courses—a situation that Booth (1988) describes with some passion:

> The great public fears us or despises us because we hire a vast army of underpaid flunkies to teach the so-called service courses, so that we can gladly teach, in our advanced courses, those precious souls who survive the gauntlet. Give us lovers and we will love them, but do not expect us to study courtship. (p. 23)

In sum, the current reform trend may produce more teachers who log more seat-time in arts and science courses. But will they know more about the subject matters they must teach? And will what they learn about the subject matters sustain them in helping diverse students learn? From the evidence on student learning in the arts and sciences, it ain't necessarily so.

What does all this imply for faculty development? One response would be communicating to faculty promising teaching approaches. A raft of advice on improving college teaching is—and has been—available (see, for instance, Chickering & Gamson, 1987; Elbe, 1972, 1980, 1988; Gullette, 1982; Levinson-Rose & Menges, 1981; McKeachie, 1986; Menges & Svinicki, 1991; Runkel, Harrison, & Runkel, 1969; Weaver, 1989; Weimer, 1987). Many of the recommendations are similar: Attend to student ideas and thinking more, lecture less; provide opportunities for students to understand the relationship between particular ideas and the "big picture" of the discipline, their own experience, and the world in which they live; represent ideas and concepts in a variety of ways to reach students who come with a variety of prior experiences and understandings; enable students to cooperate rather than compete in addressing issues and problems; design ways to investigate the subject that involve students in active inquiry; and so on.

Yet, the issue is arguably less one of technique, less a lack of knowledge about good practice and more one of values. If arts and science faculty believe that all their students can learn and their job is to figure out how to help them learn, they seek out ways to improve their practice (see, for instance, American Association for the Advancement of Science, 1990; Booth, 1988; Elbow, 1986; McDiarmid, 1991a). Unless universities, disciplinary communities, and the public at large come to value teaching and learning differently, the best advice on teaching will continue to go largely unheeded.

Arts and science faculty work within a variety of cultures that, like all cultures, value some activities over others. In the first place, they are members of disciplinary departments. These departments are, in turn, part of larger disciplinary communities that extend across institutions and national borders. Physicists, English professors, mathematicians, and historians each have their standards for judging the activities and products of the members of their culture. Generally, members of the disciplinary communities value, above all else, contributions to knowledge in their field. Also valued is the cultivation of new, contributing members of the community—that is, graduate students. Far down the list of valued activities in most disciplines is teaching undergraduates.

The institutions that employ arts and science faculty also constitute cultures. As noted above, in some institutions, the faculty and administration have, over time, cultivated undergraduate teaching as a valued activity. These institutions appear to be primarily liberal arts colleges that emphasize grantsmanship and research less than do larger, research-oriented universities. In institutions of the latter type, administrators pay lip service to the importance of teaching. Yet, promotion and tenure decisions hinge not on the quality of candidates' teaching or their students' learning but rather on their research and publications.

Despite invectives—such as Boyer's (1990)—against the fact that universities value research and publications above teaching and service, evidence of change in the activities and products institutions or disciplinary communities value and reward is scant. Even if individual institutions attempted to reconfigure the value and reward structure as reformers such as Boyer urge, faculty are also part of larger disciplinary cultures for whom, as noted, the development of new knowledge and members—not teaching undergraduates—is paramount. In addition, universities operate within the broader context of Western culture. Within this culture, teaching and learning have taken on particular meanings and are associated with particular images (Cohen, 1988; Cuban, 1984). In this context, university teaching is largely synonymous with lecturing, with the transmission of large volumes of information; learning, reciprocally, has been understood as the mastery, retention, and

reproduction of information. Other ideas and images coexist with these but are not as widely held.

That faculty members are responsible for finding out whether their students genuinely seem to be coming to understand key ideas and, if not, changing their teaching, or for providing opportunities for students to integrate new ideas and information with their prior experiences and understandings, or for helping students see the relationship between an idea and the larger issues or knowledge structures in the field have generally not been expectations within or even outside the university. Certainly, some faculty members define their responsibilities along these lines. Those who do not are usually not penalized. On the contrary, many faculty who have thrived in and been handsomely rewarded by their institutions have done so despite paying little attention to their responsibilities as teachers.

The current fiscal crisis in higher education seems likely to reinforce rather than challenge existing values. As state support of public universities declines, faculty are likely to find themselves pressured to compete for more research dollars. And, in a time of budget cuts, faculty who bring in dollars will be even more valuable in the eyes of those who shape the reward structure of universities.

One way to get arts and science faculty to attend more closely to the ideas and understandings their students hold about the subject would be to find ways for these teachers to work with faculty from teacher education. Arts and science faculty bring to such work both their grounding in their subject matter and, in some cases, considerable experience teaching the subject. Teacher education faculty, on the other hand, bring knowledge of and deep interest in pedagogy and, in some cases, knowledge of the difficulties particular subjects pose for students. At various institutions, arts and science faculty and education faculty have cooperated to help undergraduates think about the pedagogical implications of a subject matter even as they are studying it. For instance, at Millersville University in Pennsylvania, teacher education faculty attend certain arts and science courses and, together with the instructor, offer one-credit "pedagogy seminars" that examine the transformation of subject matter into representations that students can comprehend (Project 30, 1991). Kleinfeld (1992), in another recent example, reports that she invited a colleague from the English department to teach *Hamlet* to her prospective teachers who were examining a case of a secondary teacher teaching the play.

Yet examples of such cooperation are relatively scarce (for descriptions of collaborative efforts between liberal arts and teacher education, see Project 30, 1991). This is due, in part, to another issue of values: Many arts and science faculty have little regard for teacher education faculty and their programs. This lack of regard stems, in many cases,

from the belief among arts and science faculty that—in Gertrude Stein's words—"there's no there there." That is, teacher education is not a genuine discipline and can claim no body of knowledge and that teacher education courses lack substance. This perception appears related to the view many university faculty seem to take of teaching: Straightforward and unproblematic, teaching is largely a matter of telling and checking to see that students can reproduce what they have been told and read. Students who fail to learn either don't have what it takes or haven't worked sufficiently hard. (Without denying that students have greater and lesser capacities for particular subjects or that genuine understanding requires concerted, sustained effort, we can argue that teachers at least share the responsibility when students do not learn.) From this perspective on teaching and learning, what's to study, what's to know?

In the eyes of many university faculty, teacher educators are further tainted by their association with schools and teachers, neither of which commands much regard or respect in the academy. Consequently, arts and science faculty are unlikely to respond to, much less seek out, opportunities to work with teacher educators. Recommending that universities administrators devise ways and allocate funds to encourage arts and science faculty and education faculty to work, perhaps even teach, together does not address the underlying cultural issues. Current reward structures do not engender the kinds of cooperation that could lead to shifts in the ways teaching and learning are viewed and valued at universities. Yet without such change, prospective teachers seem unlikely to experience teaching, learning, and understanding that prepares them to help others learn in connected and meaningful ways.

References

American Association for the Advancement of Science. (1989). *Science for all Americans: A Project 2061 report on literacy goals in science, mathematics, and technology*. Washington, DC: Author.

American Association for the Advancement of Science. (1990). *The liberal art of science: Agenda for action*. Washington, DC: Author.

Anderson, C. W. (1991). Policy implications of research on science teaching and teachers' knowledge. In M. M. Kennedy (Ed.), *Teaching academic subjects to diverse learners* (pp. 5-30). New York: Teachers College Press.

Arons, A. B. (1990). *A guide to introductory physics teaching*. New York: Wiley.

Astin, A. (1985). *Achieving educational excellence: A critical assessment of priorities and practices in higher education*. San Francisco: Jossey-Bass.

Axtell, J. (1987). Europeans, Indians, and the age of discovery in American history textbooks. *American Historical Review, 92*, 621-632.

Ball, D. L. (1988a). *Knowledge and reasoning in mathematical pedagogy: Examining what prospective teachers bring to teacher education*. Unpublished doctoral dissertation, Michigan State University, East Lansing.

Ball, D. L. (1988b). Unlearning to teach mathematics. *For the Learning of Mathematics, 8*(1), 40-48.

Ball, D. L. (1989). *Breaking with experience in learning to teach mathematics: The role of the preservice methods course* (Issue Paper 89-10). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Ball, D. L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *Elementary School Journal, 90*, 449-466.

Ball, D. L. (1991). Teaching mathematics for understanding: What do teachers need to know about subject matter? In M. M. Kennedy (Ed.), *Teaching academic subjects to diverse learners* (pp. 63-83). New York: Teachers College Press.

Ball, D. L., & McDiarmid, G. W. (1990). The subject matter preparation of teachers. In R. Houston (Ed.), *Handbook of research on teacher education* (pp. 437-449). New York: Macmillan.

Ball, D. L., & Wilson, S. W. (1990). *Knowing the subject and learning to teach it: Examining assumptions about becoming a mathematics teacher* (Research Report No. 90-7). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Banks, J. (1971). Relevant social studies for black pupils. In J. Banks & W. Joyce (Eds.), *Teaching social studies to culturally different children* (pp. 202-209). Reading, MA: Addison-Wesley.

Banks, J. (1991). Social science knowledge and citizenship education. In M. M. Kennedy (Ed.), *Teaching academic subjects to diverse learners* (pp. 117-128). New York: Teachers College Press.

Beers, S. (1988). Epistemological assumptions and college teaching: Interactions in the college classroom. *Journal of Research and Development in Education, 21*(4), 87-94.

Bestor, A. (1985). *Educational wastelands: The retreat from learning in our public schools* (2nd ed.). Urbana: University of Illinois Press. (Original work published 1953)

Bird, T. (1991). *Making conversations about teaching and learning in an introductory teacher education course* (Craft Paper 91-2). East Lansing: Michigan State University, National Center for Research on Teacher Learning.

Booth, W. C. (1988). *The vocation of a teacher: Rhetorical occasions, 1967-1988.* Chicago: University of Chicago Press.

Boyer, E. (1987). *College: The undergraduate experience in America.* New York: Harper & Row.

Boyer, E. (1990). *Scholarship reconsidered: Priorities of the professorate.* Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Buchmann, M. (1984). The priority of knowledge and understanding in teaching. In L. G. Katz & J. D. Raths (Eds.), *Advances in teacher education* (Vol. 1, pp. 29-50). Norwood, NJ: Ablex.

Cannon, J. (1984). *Teaching history at university.* London: Historical Association.

Champagne, A. B., Gunstone, R. F., & Klopfer, L. E. (1985). Effecting changes in cognitive structures among physics students. In L. H. T. West & A. L. Pines (Eds.), *Cognitive structure and conceptual change* (pp. 163-187). New York: Academic Press.

Chickering, A. W., & Gamson, Z. F. (1987). Seven principles for good practice in undergraduate education. *American Association for Higher Education Bulletin, 39*(7), 3-7.

Clement, J. (1982). Students' preconceptions in introductory mechanics. *American Journal of Physics, 50*, 66-71.

Clement, J., Lochhead, J., & Monk, G. S. (1981). Translation difficulties in learning mathematics. *American Mathematical Monthly, 8*, 286-290.

Clift, R. T. (1987). English teacher or English major: Epistemological differences in the teaching of English. *English Education, 19*, 229-236.

Cohen, D. K. (1988). *Teaching practice: Plus ça change . . .* (Issue Paper 88-3). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Cohen, D. K., Peterson, P. L., Wilson, S., Ball, D., Putnam, R., Prawat, R., Heaton, R., Remillard, J., & Wiemers, N. (1990). *Effects of state-level reform of elementary school mathematics curriculum on classroom practice* (Research Report No. 90-14). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Coleman, E. (1984). *An ethnographic description of the development of basic writers' revision skills*. In ERIC Document Reproduction Service No. ED 283 151.

Conant, J. (1963). *The education of American teachers*. New York: McGraw-Hill.

Cuban, L. (1984). *How teachers taught: Constancy and change in American classrooms, 1890-1980*. New York: Longman.

Current, R. (1988). *Those terrible carpetbaggers: A reinterpretation*. New York: Oxford University Press.

Dijksterhuis, E. J. (1969). *The mechanization of the world picture*. London: Oxford University Press.

Doyle, W. (1986). Content representation in teachers' definitions of academic work. *Journal of Curriculum Studies, 18*, 365-379.

DuBois, W. E. B. (1935). *Black reconstruction in America*. New York: Harcourt, Brace.

Duckworth, E. (1987). *"The having of wonderful ideas" and other essays on teaching and learning*. New York: Teachers College Press.

Dunkin, M. J., & Barnes, J. (1986). Research on teaching in higher education. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 754-777). New York: Macmillan.

Elbe, K. E. (1972). *Professors as teachers*. San Francisco: Jossey-Bass.

Elbe, K. E. (Ed.). (1980). *Improving teaching styles*. (New Directions for Teaching and Learning, No. 1). San Francisco: Jossey-Bass.

Elbe, K. E. (1988). *The craft of teaching* (2nd ed.). San Francisco: Jossey-Bass.

Elbow, P. (1986). *Embracing contraries: Explorations in learning and teaching*. New York: Oxford University Press.

Fitzgerald, F. (1979). *America revisited*. Boston: Atlantic-Little, Brown.

Floden, R. E., McDiarmid, G. W., & Wiemers, N. (1990). *Learning about mathematics in elementary methods courses*. (Research Report 90-1). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Foner, E. (1988). *Reconstruction: America's unfinished revolution, 1863-1877*. New York: Harper & Row.

Gagnon, P. (1988, November). Why study history? *Atlantic Monthly*, pp. 43-66.

Graff, G. (1987). *Professing literature: An institutional history*. Chicago: University of Chicago Press.

Graves, D. H. (1981). Writing research for the eighties: What is needed. *Language Arts, 58*(2), 202.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.

Gullette, M. M. (Ed.). (1982). *The art and craft of teaching*. Cambridge, MA: Harvard University, Harvard-Danforth Center for Teaching and Learning.

Hexter, J. H. (1979). *On historians: Reappraisals of the masters of modern history*. Cambridge, MA: Harvard.

Hines, C., Cruickshank, D., & Kennedy, J. (1985). Teacher clarity and its relationship to student achievement and satisfaction. *American Educational Research Journal, 22*, 87-99.

Hirsch, E. D., Jr. (1987). *Cultural literacy: What every American needs to know*. New York: Vintage.

Johnson, C. (1990). *Middle passage*. New York: Plume.

Karplus, R. (1974). *Science curriculum improvement study: Teacher's handbook*. Berkeley, CA: Lawrence Hall of Science.

King, J. E., & Ladson-Billings, G. (1990, April). *Dysconscious racism and multicultural illiteracy: The distortion of the American mind*. Paper presented at the annual meeting of the American Educational Research Association, Boston.

Kleinfeld, J. S. (1992, April). *Can cases carry pedagogical content knowledge? Yes, but we've got signs of a "Matthew effect."* Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Kline, M. (1977). *Why the professor can't teach: Mathematics and the dilemma of university education*. New York: St. Martin's Press.

Kramer, R. (1991). *Ed School Follies*. New York: Free Press.

Kulik, J., & Kulik, C. (1979). College teaching. In P. L. Peterson & H. J. Walberg (Eds.), *Research on teaching: Concepts, findings, and implications* (pp. 70-93). Berkeley, CA: McCutchan.

Lampert, M. (1985). How do teachers manage to teach? Perspectives on problems of practice. *Harvard Educational Review, 55*, 178-194.

Leinhardt, G. (1987). Development of an expert explanation: An analysis of a sequence of subtraction lessons. *Cognition and Instruction, 4*, 225-282.

Leinhardt, G., & Smith, D. (1985). Expertise in mathematics instruction: Subject matter knowledge. *Journal of Educational Psychology, 77*, 247-271.

Levinson-Rose, J., & Menges, R. (1981). Improving college teaching: A critical review of research. *Review of Educational Research, 51*, 403-434.

London, H. (1984). *Why are they lying to our children*? New York: Stein & Day.

Lynch, J. R. (1913). *The facts of reconstruction*. New York: Harcourt, Brace.

Maestre, J. P., Gerace, W. J., & Lochhead, J. (1983). The interdependence of language and translational math skills among bilingual Hispanic engineering students. *Journal of Research in Science Teaching, 19*, 339-410.

Maestre, J. P., & Lochhead, J. (1983). The variable-reversal error among five culture groups. In J. C. Bergeron & N. Herscovics (Eds.), *The fifth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 180-189). Montreal: North American Chapter of the International Group for the Psychology of Mathematics Education.

McDermott, L. (1984). Research on conceptual understanding in mechanics. *Physics Today, 37*, 24-32.

McDiarmid, G. W. (1990). Challenging prospective teachers' beliefs during an early field experience: A quixotic undertaking? *Journal of Teacher Education, 41*(3), 12-20.

McDiarmid, G. W. (1991a, April). *A case of historical pedagogy: How an instructor's view of history and learning are incorporated in an undergraduate history workshop*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

McDiarmid, G. W. (1991b). What teachers need to know about cultural diversity: Restoring subject matter to the picture. In M. M. Kennedy (Ed.), *Teaching academic subjects to diverse learners* (pp. 257-270). New York: Teachers College Press.

McDiarmid, G. W., Ball, D. L., & Anderson, C. W. (1989). Why staying one chapter ahead doesn't really work: Subject-specific pedagogy. In M. C. Reynolds (Ed.), *Knowledge base for the beginning teacher* (pp. 193-205). New York: Pergamon.

McDiarmid, G. W., Wiemers, N. J., & Fertig, L. (1991, April). *Bounded by their pasts: Exploring the relationship between understandings of history and the views of teaching and learning of history among majors in a historiography seminar*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

McDiarmid, G. W., & Wilson, S. W. (1991). An exploration of the subject matter knowledge of alternate route teachers: Can we assume they know their subject? *Journal of Teacher Education, 42*(3), 93-103.

McKeachie, W. J. (1986). *Teaching tips: A guidebook for the beginning college teacher* (8th ed.). Lexington, MA: Heath.

McKeachie, W., Pintrich, P., Lin, Y., & Smith, D. (1986). *Teaching and learning in the college classroom: A review of the research literature*. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning.

McMillan, J. (1987). Enhancing college students' critical thinking: A review of studies. *Journal of Higher Education, 26*, 3-29.

Menges, R. J., & Svinicki, M. D. (1991). *College teaching: From theory to practice.* (New Directions for Teaching and Learning, No. 45). San Francisco: Jossey-Bass.

Miller, J. L. (1983). A search for congruence: Influence of past and present in future teachers' concepts about teaching writing. *English Education, 15,* 5-16.

NCRTE. (1991). *Teacher education and learning to teach study: Final report.* East Lansing: Michigan State University, National Center for Research on Teacher Education.

National Council of Teachers of Mathematics. (1989a). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1989b). *Professional standards for teaching mathematics: Working draft.* Reston, VA: Author.

National Research Council. (1989). *Everybody counts: A report to the nation on the future of mathematics education.* Washington, DC: National Academy Press.

National Research Council. (1991). *Moving beyond the myths: Revitalizing undergraduate mathematics.* Washington DC: National Academy Press.

Nicholls, D. (1984). College level history in the United States. *History Teacher, 18*(1), 57-67.

Novick, P. (1988). *That noble dream: The "objectivity question" and the American historical profession.* Cambridge, England: Cambridge University Press.

O'Brien, W. A. (1984, October). *Modernization and the changing nature of community in colonial America: A "moment" in the United States history survey course at J. Sargeant Reynolds Community College, Richmond, Virginia.* Paper presented at the annual meeting of the Community College Humanities Association, Charleston, SC.

Pascarella, E. T., & Terenzini, P. (1991). *How college affects students.* San Francisco: Jossey-Bass.

Perkins, D. (1986). *Knowledge as design.* Hillsdale, NJ: Erlbaum.

Pollio, H. (1984). *What students think about and do in college lecture classes* (Teaching-Learning Issues No. 53). Knoxville: University of Tennessee.

Project 30. (1991). *Year two report: Institutional accomplishments.* Newark, DE: University of Delaware Press.

Project on Redefining the Meaning and Purpose of Baccalaureate Degrees. (1985). *Integrity in the college curriculum*. Washington, DC: Association of American Colleges.

Ravitch, D. (1989). The plight of history in American schools. In P. Gagnon & Bradley Commission on History in Schools (Eds.), *Historical literacy* (pp. 51-68). New York: Macmillan.

Rickover, H. G. (1960). *Education and freedom*. New York: E. P. Dutton.

Rigden, J. S., & Tobias, S. (1991). Too often, college-level science is dull as well as difficult. *Chronicle of Higher Education, 37*(28), 52.

Ritchie, J. S. (1989). Beginning writers: Diverse voices and individual identity. *College Composition and Communication, 40*(2), 152-174.

Rosaen, C. R., Roth, K. J., & Lanier, P. E. (1988). *Learning to teach subject matter: Cases in English, mathematics, and science*. Paper presented at the midwest regional meeting of the Holmes Group, Chicago.

Rosenquist, M. L., & McDermott, L. E. (1987). A conceptual approach to teaching kinematics. *American Journal of Physics, 55*, 407.

Runkel, P., Harrison, R., & Runkel, M. (Eds.). (1969). *The changing college classroom*. San Francisco: Jossey-Bass.

Schama, S. (1991). *Dead certainties (unwarranted speculations)*. New York: Knopf.

Scheffler, I. (1973). *Reason and teaching*. New York: Bobbs-Merrill.

Schoenfeld, A. (1985). Metacognitive and epistemological issues in mathematical understanding. In E. A. Silver (Ed.), *Teaching and learning mathematical problem-solving: Multiple research perspectives* (pp. 361-379). Hillsdale, NJ: Erlbaum.

Schwab, J. J. (1964). The structures of the disciplines: Meanings and significances. In G. W. Ford & L. Pugno (Eds.), *The structure of knowledge and the curriculum*. Chicago: Rand McNally.

Sewall, G. T. (1987). *American history textbooks: An assessment of quality*. New York: Columbia University, Teachers College, Educational Excellence Network.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(5), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 1-23.

Simmonds, J. C. (1989). History curriculum and curriculum change in colleges and universities of the United States: A study of twenty-three history departments in 1988. *History Teacher, 22*(3), 293-316.

Smith, P. (1990). *Killing the spirit: Higher education in America.* New York: Viking Penguin.

Study Group on the Conditions of Excellence in American Higher Education. (1984). *Involvement in learning: Realizing the potential of American higher education.* Washington, DC: National Institute of Education.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier.* Tucson, AZ: Research Corporation.

Tomlinson-Kreasey, C., & Eisert, D. (1978). Second year evaluation of the ADAPT program. In R. Fuller (Ed.), *Multidisciplinary Piagetian-based programs for college freshmen: ADAPT.* Lincoln: University of Nebraska.

Trowbridge, D. E., & McDermott, L. C. (1981). Investigations of student understanding of the concept of acceleration in one dimension. *American Journal of Physics, 49*, 242.

Viennot, L. P. H. (1979). *Le raisonnement spontané en dynamique élémentaire.* Paris: Hermann.

Watts, D. G. (1972). *The learning of history.* London: Routledge & Kegan Paul.

Weaver, F. S. (Ed.). (1989). *Promoting inquiry in undergraduate learning* (New Directions for Teaching and Learning, No. 38). San Francisco: Jossey-Bass.

Weimer, M. G. (Ed.). (1987). *Teaching large classes well* (New Directions for Teaching and Learning, No. 32). San Francisco: Jossey-Bass.

Whitla, D. K. (1977). *Value added: Measuring the outcomes of undergraduate education.* Cambridge, MA: Harvard College Press.

Wilson, S. W. (1991). Parades of facts, stories of the past: What do novice history teachers need to know? In M. M. Kennedy (Ed.), *Teaching academic subject matter to diverse learners* (pp. 99-116). New York: Teachers College Press.

Wilson, S. M. (in press). Mastodons, maps, and Michigan: Exploring uncharted territory while teaching elementary school social studies. *Elementary School Journal*.

Wilson, S. M., Shulman, L. S., & Richert, A. E. (1987). "150 different ways" of knowing: Representations of knowledge in teaching. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp. 104-124). London: Cassell.

Wilson, S. M., & Sykes, G. (1989). Toward better teacher preparation and certification. In P. Gagnon & the Bradley Commission on History in Schools (Eds.), *Historical literacy: The case for history in American education* (pp. 268-286). New York: Macmillan.

Wilson, S. M., & Wineberg, S. S. (1988). Peering at history from different lenses: The role of disciplinary perspectives in the teaching of American history. *Teachers College Record, 89*, 525-539.

Winter, D., McClelland, D., & Stewart, A. (1981). *A new case for the liberal arts: Assessing institutional goals and student development*. San Francisco: Jossey-Bass.

Woodward, C. V. (1986). *Thinking back*. Baton Rouge: Louisiana State University Press.

Young, R. E. (1987). Epistemologies. In M. J. Dunkin (Ed.), *The international encyclopedia of teaching and teacher education* (pp. 493-496). Oxford, England: Pergamon.